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LEON GASTER

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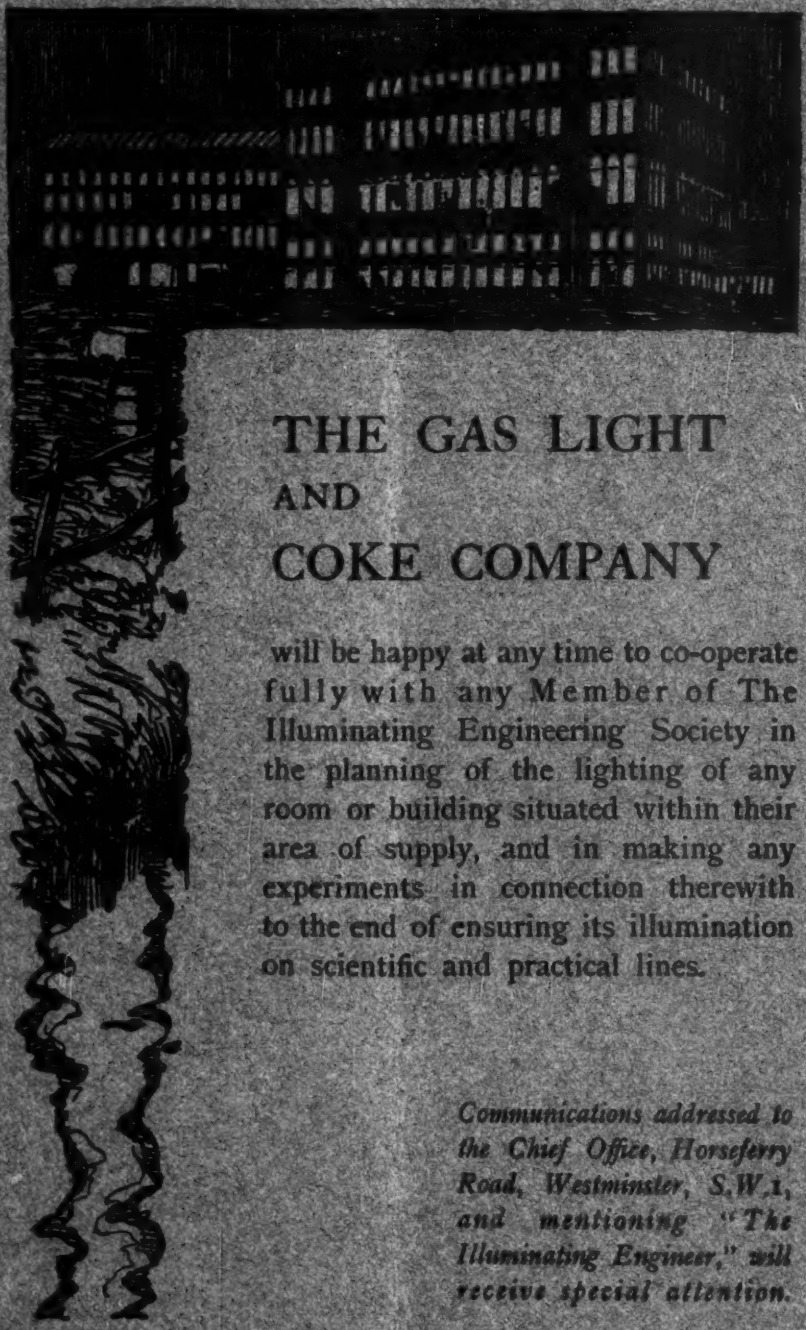
This Number contains an Account of the Proceedings at the Meeting of **The Illuminating Engineering Society** on December 12th, 1922, including:—

Other items include an account of an important investigation on **The Effect of Lighting Conditions on Output in Coal Mines.**



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EDITORIAL.

Street Lighting Requirements and Developments.

The discussion on street lighting before the Illuminating Engineering Society on December 12th was opportune. There is a general impression that the time has come to put in hand schemes of renovation postponed during the War and in subsequent years. Ideas on public lighting are constantly undergoing development, and it was remarked in the discussion that the subject needed reviewing every few years. The last occasion on which it was specially dealt with by the Society was in April, 1913, when Mr. Trotter delivered his paper on the Standard Specification. It was therefore a great pleasure to welcome Mr. Trotter, who came up to London specially to preside.

At this meeting we were also favoured by the presence of Dr Clayton Sharp, who is a past-president of the American Illuminating Engineering Society, a recognised expert on photometry and street lighting, and the Chairman of the Technical Committee of the International Illumination Commission on Motor Headlights. Dr. Sharp has since contributed a sympathetic account of the proceedings to the journal of the Illuminating Engineering Society in the United States, in the course of which he suggested occasional joint meetings of the two societies. We hope that at some future

time it will be possible to arrange such meetings, which, as Dr. Sharp remarks, would be of great interest and profit to both organisations.

In the course of the discussion many points raised on the occasion of Mr. Trotter's paper in 1913 were again the subject of comment. On such questions as the merits of candlepower and illumination as a basis of specification some difference of opinion still exists. But we were glad to note a general recognition that, whatever the precise basis adopted, *some* method of ensuring that the public receive the light for which they pay should be inserted in modern street-lighting contracts. Captain H. L. Thomson, for many years chairman of the Public Lighting Committee of the City of Westminster, recalled old contracts, now superseded, in which there was no provision as regards distribution of light. It should also be recognised that a mere stipulation of the amount of light furnished (whether specified as candlepower or illumination), though important, is not the only point to consider. The exhaustive tests undertaken in some American cities and described by Dr. Clayton Sharp form an interesting object lesson. Entire lengths of street were lighted experimentally, and measurements of illumination were supplemented by practical tests of " revealing power " and consideration of freedom from glare and decorative appearance.

Other points raised in the discussion related chiefly to distribution of light. In modern street lighting special devices are employed to concentrate the light at angles slightly below the horizontal, in order to illuminate effectively the parts of the street most remote from the source. In such circumstances care is necessary to avoid glare, and the best solution of the problem is found in those cases where the light is not only redirected but softened by the aid of globes and lanterns of diffusing glass. Another question is the proportion of light that should be allotted respectively to pavements and to the surfaces of buildings. In narrow streets, and in cases where considerations of economy limit the amount of light available, it may be necessary to confine the light chiefly on the pavement and road. But in imposing main thoroughfares, lined by buildings of architectural merit, there is much to be said for Captain Thomson's view that the revealing of the surfaces of the buildings is an important consideration. In such streets, as he rightly remarked, the co-operation of architects in deciding on the method of lighting would be extremely useful.

The discussion revealed a general recognition of the great importance of public lighting, which was well expressed by Mr. Frank Bailey. It was useful to hear the views of several inspectors of public lighting, some of whom had come to London from cities in the Provinces, and to realise the difficulties that are sometimes felt in inducing authorities to make the necessary expenditure on lighting the streets. It should be realised that the cost of public lighting is small compared with that of other public services maintained by the city. From the data presented by Mr. Langlands it appears that in Glasgow the annual expenditure only amounts to about 5s. per head of population. According to some figures recently presented in the United States by Mr. H. E. Butler the cost of adequate lighting is only a small proportion of the expenditure on the upkeep of roads, and a somewhat similar ratio applies to the cost of installation. On the other hand the advantage to the public of well-lighted streets is very great. In many cases the saving in consumption arising from the introduction of more efficient lighting appliances would probably be sufficient to pay for the cost of the installation within a short period.

The Circle of Scientific, Technical and Trade Journalists.

On several occasions we have gladly acknowledged the valuable services rendered by the technical Press in making the work of the Illuminating Engineering Society more widely known. We therefore record with pleasure the progress of the Circle of Scientific, Technical and Trade Journalists, which affords opportunities for the exchange of views between journalists on many subjects of common interest. In May last year steps were taken to promote the resumption of its full activities, and there have since been several interesting visits and discussions.

On January 9th, when the annual meeting, preceded by a dinner in the Hall of the Institute of Journalists, was held, the writer was able to present an encouraging report on progress. It was felt that the moment was opportune to extend the work of the Circle, which deserves to be more widely known. Sir Richard Gregory, who is equally identified with science and journalism, has consented to accept the Chairmanship, and a representative Committee was elected. At the termination of formal business an admirable address on " Reviews and Reviewers " was given by the Chairman, and in the subsequent discussion many points of general interest were raised.

The Editor, who frequently receives more books for review than he can notice, has many problems to consider. The selection of books for review is determined mainly by the special field of the journal to which they are sent. But in general space can only be afforded for a short notice, except in the case of works of outstanding importance. Most of those who spoke in the discussion agreed that books of this type ought to be submitted to an acknowledged expert for review. Yet technical knowledge is only one of the requisites in a reviewer. He must also be able to take a broad view of the subject, considering the interests of readers, but without being hypercritical. He should, for instance, endeavour to give an idea of the contents of the book and not confine himself mainly to searching for small inaccuracies.

Much difference of opinion has been expressed in regard to the question of anonymity of reviews. In the majority of cases reviews are unsigned, but there is something to be said for the view that, in the case of a full analysis of an important work, it is an advantage for the review to bear the hall-mark of an expert whose opinions would carry weight. Another question that arises is the desirability of a book being reviewed in a number of journals by the same reviewer. In practice this is not unusual, especially in connection with a subject of which only a few have special knowledge. The reviewer in this case should realise that he has special responsibility, as the reception of a book may be largely influenced by his comments in different papers.

The meeting should serve a useful purpose in promoting discussion of these and other debatable questions, and it is to be hoped that it will pave the way for general agreement on a few fundamental principles on the part of editors of scientific and technical journals.

The Effect of Illumination on Output in Coal Mines.

The important relation of conditions of lighting in coal mines to the eyesight and well-being of the worker was very fully discussed at a meeting of the Illuminating Engineering Society in February, 1920, and it will be recalled that the report of the Miner's Nystagmus Committee published last year fully confirmed the belief that this disease of eyesight is due primarily to inadequate illumination. In a striking contribution to the Journal of the National Institute of Psychology, Messrs. E. Farmer, S. Adams and A. Stephenson attack the subject from a different aspect—the effect of conditions of lighting on output. As is well known, the chief difficulty in designing miners' lamps is to obtain the desired candlepower without the weight of the lamp and battery becoming excessive. In these experimental tests, however, volunteers undertook to work for an eight-week period, first by the light of the ordinary lamp and then by the aid of a special " porch lamp " giving a light about six times as great though approximately five times as heavy. A careful record of output was kept, and it was found that the increased illumination led to an increase of 14·57 per cent. in the net coal output.

It is remarked that since the workers voluntarily carried a lamp of five times the normal weight for eight weeks there is ground for suggesting that the weight of the ordinary lamp might at least be *doubled* in order to obtain more light without the weight being a serious handicap. The beneficial effect of this increase in weight would also allow a margin of intensity which would permit diffusion of the light by a slightly opaque cylinder, adding to the comfort of vision. The investigators also draw attention to another weakness in the ordinary lamp, the exposure of unscreened filaments which, though of low candlepower, appear glaring in relation to the dark surroundings and may therefore be a contributory cause of defects of vision. It was found that shading the standard lamp with a diffusing cylinder materially reduced the number and duration of " after images." A miner who suffered from nystagmus also stated that he found the shaded lamp very much less trying, and in a number of cases the visual acuity was actually better with the shaded lamp, notwithstanding the fact that the use of the opaque cylinder somewhat diminished the light.

There are other recommendations that deserve careful consideration, notably in regard to the use of a suitable reflector, and it will be recalled that at the meeting of the Illuminating Engineering Society in November last particulars were given of a new type of lamp in which a substantial gain in illumination was obtained in this way.

The research is a striking confirmation of the views expressed before the Illuminating Engineering Society in regard to the effect of lighting conditions in mines. No doubt the Institute will apply the same methods to the investigation of other industries. In a factory conditions are somewhat different, as we are not dealing with the extremely feeble order of illumination met with in mines ; but, nevertheless, investigations would doubtless show that improved illumination is beneficial in diminishing accidents and spoiled work, and in preventing the output falling below the recognised standard attainable under good working conditions.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

RECENT DEVELOPMENTS AND MODERN REQUIREMENTS IN STREET LIGHTING.

(Proceedings at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on December 12th, 1922.)

Joint Meeting with the Institution of Gas and Electrical Engineers and the Institution of Municipal and County Engineers.

A MEETING of the Society took place as stated above, the Chair being occupied by Mr. A. P. TROTTER.

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the name of the following applicant for membership :—

W. J. JONES .. .. Electrical Engineer, Messrs. English Electric & Siemens Supplies, Ltd., 39, Upper Thames Street, E.C. 4.

THE CHAIRMAN (Mr. A. P. Trotter) then called upon Mr. HAYDN T. HARRISON to read his paper on **"Recent Developments and Modern Requirements in Street Lighting,"** after which MR. L. GASTER delivered a short address on **"Street Lighting in relation to Safety,"** in which reference was made to the intimate relation between conditions of public lighting and accidents in streets, and to the desirability of a central authority to supervise the lighting of London as a whole.

THE CHAIRMAN (Mr. A. P. Trotter) recalled the discussion on the Draft Standard Specification for Street Lighting which he had initiated in 1913, and mentioned that the members of the other bodies concerned in the framing of this specification (the Institutions of Gas and Electrical Engineers and the Institution of Municipal and County Engineers) had been invited to be present.

In the ensuing discussion Dr. CLAYTON H. SHARP (Past President of the Illuminating Engineering Society, U.S.A.), Mr. FRANK BAILEY, Capt. W. J. LIBERTY (Public Lighting Inspector to the City of London), Mr. S. B. LANGLANDS (Public Lighting Inspector, City of Glasgow), Mr. J. G. CLARK, Mr. R. DAVISON (Lighting Superintendent Newcastle-on-Tyne), and Mr. H. L. THOMSON (Chairman of the Lighting Committee, City of Westminster) took part.

Mr. Harrison having briefly replied to the discussion, a vote of thanks to the author and to Mr. Trotter terminated the proceedings, and members signified their pleasure at seeing Mr. Trotter again presiding over a meeting of the Society.

In conclusion it was announced that the **next meeting** would be held at **8 p.m.** on Tuesday, **January 16th, 1923,** when a discussion on **"The need for Suitable Training in Illuminating Engineering"** would be opened by Mr. C. E. Greenslade and Mr. J. E. S. White.

STREET LIGHTING REQUIREMENTS.

By HAYDN T. HARRISON, M.I.E.E.

(Introduction to the Discussion at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, December 12th, 1922.)

THERE is no need to go into the early history of street lighting, but I would remind you that lighting the streets was first started with the object of reducing crime, and that this is still of primary importance. The late George R. Sims is credited with the statement that one arc lamp is worth two policemen; this principle still holds good; there is any quantity of evidence to the effect that crime more generally occurs in the slums and badly-lighted streets, where the police find it difficult either to prevent it or capture the criminals. It must also be remembered that such places harbour not only the criminals of to-day, but also those who are being bred under circumstances which encourage criminal tendencies from their youth.

Sanitation, water supply, the physical and moral health of these degenerates receive more and more attention as time goes on, but who ever hears of steps being taken to improve the lighting of the streets, lanes and alleys which form their playground from childhood?

Should there be representatives of municipalities here to-night I would ask them to bear in mind this most important feature of that which comes under the heading of street lighting.

I know that the burden of the rates is already high and to add to them by further expense such as would be incurred by improving the conditions of street lighting is out of the question, but I would point out that improving street lighting does not always mean increased expenditure, and when even that is so it is often saved in other directions, such as the expenditure on criminal institutions, prisons, etc., and by reducing the number of police necessary.

Another feature of the historical side of which I would remind you is, that at one time pedestrians used to carry lanterns, just as vehicles are compelled to carry them now.

This raises an interesting point, namely, that it would appear to be the opinion of the authorities that the present street lighting is good enough for pedestrians but not so for vehicular traffic.

I conclude the difference lies in the speed at which they move. A vehicle is a larger object than a pedestrian, and therefore should be visible at a greater distance; moreover, it makes more noise and its approach should be notified by the ear, and yet it is not considered safe to allow it to travel without lights.

From the fact that the driver of a vehicle is held responsible for any damage he may do to a pedestrian (who carries no light) it would appear that the lights carried by the vehicle are not for the purpose of warning the pedestrian but to illuminate and make known his presence so that the driver may avoid an accident.

If this is the object of such lights is it surprising that the faster moving vehicles provide themselves with powerful headlights?

Much has been heard lately about the nuisance caused by these powerful headlights, but the fact that nothing has been legally enacted in this country which redresses this nuisance goes to prove that those responsible are of opinion that more accidents would occur if they were dispensed with.

To avoid the necessity for these headlights it is essential that pedestrians and obstruction should be made visible to the drivers by other means, such as street lamps. Thus we arrive at the point that a standard of street illumination is necessary to prevent crime and accidents. This point has been often discussed by various committees who have investigated the subject. The Joint Street Lighting Committee, which carried out investigations during the years 1911 and 1912 did much useful work. The result of which was embodied in a paper read by Mr. A. P. Trotter before this Society in April, 1913, under the title "Standard Clauses for Inclusion in a Specification of Street

Lighting." Those who have carefully studied this paper will have noted the Joint Committee represented nearly everybody concerned, municipal engineers, gas engineers, electrical and illuminating engineers and the police. Street lighting conditions were studied both from the physiological and photometric point of view, and that eventually the majority agreed upon a method classifying street lighting, and means to be adopted for testing same.

The method of classification was based on the minimum horizontal illumination as measured one meter (3 ft. 3⅜ ins.) above the ground.

In my opinion the scientific soundness of this method of classification does not leave much room for discussion if the meaning of horizontal illumination and all the factors which effect it are clearly understood, which I regret to say is very often not the case.

Street illumination is nearly universally provided by light sources erected at distances many times their height, with the result that the rays which penetrate to the point of minimum illumination (that is, the farthest distance from the light sources) very closely approach the horizontal, and are therefore at a very acute angle to the horizontal plane. It is well to remember that the horizontal illumination decreases at a rate equal to the cube of the distance from the light sources, in accordance with the well-known inverse square and cosine laws.

Few appreciate the fact that if minimum horizontal illumination is taken as the criterion of street lighting, the illumination would at the distance and height street lamps are usually placed, be more than doubled by doubling the height of the lamps, and increased nearly eight times by halving the distance apart of the lamps.

For example, lamps 60 yds. apart, 12 ft. high, give only one-twentieth the minimum horizontal illumination resulting from the same lamps 30 yds. apart, 24 ft. high.

Thus without providing any more luminous energy the illumination of a street according to the standard laid down by that Joint Committee can be increased ten times by re-arrangement of the spacing of the lighting units.

Another important factor is light distribution. Nearly every light source distributes its energy fairly evenly over a spherical area. For many years a large part of the upper hemispherical energy has been diverted into the lower hemisphere, but for obvious reasons it has generally found its way into the section approaching the vertical and not the horizontal, where it is required for distant illumination.

The Holophane Co., by means of their prismatic globes, have succeeded in increasing the luminous energy in this desired direction from 2 to 2½ times the average.

But even this is a small increase when it is borne in mind that by this circular distribution area much of the luminous energy is used in brilliantly illuminating either the frontage adjacent to the light sources or the surrounding country which formed no part of the road or street to be lighted.

To realise this, take the previous example of lamps 60 yds. apart, each of which illuminates a circle 180 ft. in diameter, having an area of 24,600 sq. ft., out of which it is only required to illuminate a strip of road 40 ft. wide, representing 7,200 sq. ft., which means that less than a third of the illuminated area is utilised.

In order to prevent this serious loss of luminous energy, I devised what is known as the Longitudinal System of street lighting. By this device the luminous energy radiating from the lower hemisphere of the source is not interfered with, but that of the upper hemisphere is collected in a special reflector which concentrates it into an angle of about 20 or 30 degrees; these rays are divided by two lower reflectors mounted radial to the original light source into two directions, namely, up and down the road in such a manner as to supplement the lower hemispherical rays beyond the point where their power is not sufficient to produce the desired illumination, the power of this supplementary reflected rays increasing as the distance increases.

It will be noted that the dispersion of 20 to 30 degrees will more than cover the width of the road at the distance where these rays come into operation, and that as the angle narrows due to the greater

distance the power is proportionately increased.

The efficiency of such a device can be realised when it is mentioned that the power of the distant rays is increased to eight or ten times that of the light source, and a still more important feature will be noted, namely, that these rays are reduced in power as the light source is approached.

The fact that I am responsible for this device must not be taken as indicating that I advocate the use of very powerful light sources in the street, but that I realise that if lamps are to be placed at the distance and height now prevailing such powerful light sources are necessary in order to obtain the minimum illumination desirable for present-day conditions.

This is best shown by an example. According to the Report before referred to 0·1 foot-candles was considered the minimum desirable for a well-lighted street; to obtain this with lamps 60 yds. apart and 20 ft. high it is necessary to have light sources giving 2,300 candlepower at about 10 degrees from the horizontal, which can be reduced as low as 50 candlepower (if desired) at angles approaching to vertical.

A lamp giving, say, 2,500 candlepower, even if the light source is increased in area by a globe or similar device, is very brilliant and would produce the effect of glare; nevertheless if the minimum standard of horizontal illumination is to be maintained, such lamps must be used and are used.

In order to illustrate principles of street lighting it is of interest to consider the various types of reflectors illustrated in Figs. 1–5. Fig. 1, which emanated from the United States, is intended for lamps placed at considerable heights and at short distances apart. Otherwise it will be noted from Fig. 2, which shows the reflector area visible from a distance, that practically no illumination would result between lamps. Figs. 4 and 5 show types of reflectors more commonly used in this country. The type illustrated in Fig. 4 very slightly affects the light distribution but materially improves the value of the lamp for street lighting by reducing the glare due to brilliantly illuminated reflector area adjacent to it. Fig. 5 represents a considerable improvement on Fig. 4 and has been devised by Mr. Cramb, the municipal electrical engineer of Croydon. This reflector has concave surfaces which enclose a considerable proportion of the luminous flux, thus increasing the illumination as well as reducing the glare.

Fig. 3 shows the means of applying the longitudinal system of lighting previously mentioned. The lower reflectors, being mirrored surfaces, have an intrinsic brilliance approaching that of the lamp filament and resemble the opalescent globes used with flame arcs.

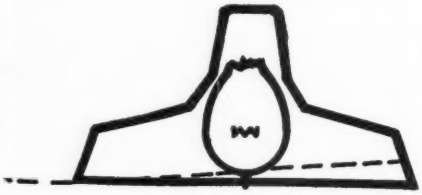

FIG. 1.

The results of the longitudinal method are illustrated in Figs. 6, 7 and 8, and are self explanatory. It is worthy of note that the distant candlepower in that part of the street which is generally so poorly lighted is seven times that of the lamp itself; whereas, when a circular distribution is aimed at, as shown by the smaller curve in Fig. 1, it rarely exceeds 2½ times.

FIG. 2.

While on the subject of glare, I would like to refer to motor-car headlights. These, if placed 5 ft. above the ground, would, in order to produce 0·1 foot-candles horizontal illumination at 100 ft. distance, have to produce 20,000 candlepower.

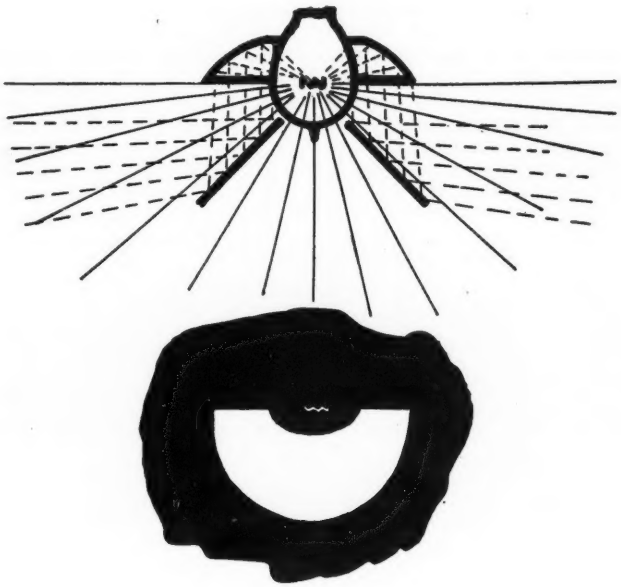

FIG. 3.

The Report of the American Committee, after much investigation of the requirements to be fulfilled for safe driving, stated "that no driving should be permitted where the road illumination is less than 0·001 foot-candles, but this would not provide sufficient illumination to distinguish dark objects even at 100 ft., and, therefore, must be taken as the very minimum illumination required; and it will be noted that should it be possible to go as low as this figure, no headlights would be required in any of the streets referred to in Mr. Trotter's paper.

Mr. Preston S. Millar, of America, has divided the requirements of street lighting as follows:—

(*a*) In portions of cities in which evil resorts exist the police protection factor is the first importance.

(*b*) In inter-urban highways the marking of the way and provision against collisions are essential.

(*c*) The dignified high class avenue must be lighted as to reveal its character by exhibiting to advantage the architectural features of the buildings.

(*d*) To serve the purpose of the auto-

FIG. 4.

FIG. 5.

mobilist raised places, or depressions in the roadway, should be revealed and the curb or limitations of the drive-way should be perceptible. Safety requires that he must detect the presence of objects at a single glance.

The Street Lighting Committee of the National Electric Light Association of America summarised the requirements as follows :—

(1) Discernment of large objects in the street and upon the sidewalk.

(2) Discernment of surface irregularities on the street and on the sidewalk.

(3) Good general appearance of street lighting.

It would be thought that all these requirements would be covered by ensuring a sufficiently high minimum horizontal illumination.

It has been amply proved by tests that at points where the illumination is low visibility is increased by sharp shadows or silhouetting the objects against the lighter illuminated background. The same tests have even tended to prove that obstructions of which the illumination was only one-tenth of those near the light source were more visible, due to the sharper silhouetting.

In America, where so much emphasis has been laid on the above factors, the Street Lighting Committee of the National Electric Light Association came to no definite conclusion on the subject of minimum illumination, but Mr. C. F. Lacombe published a table of grading of which the following is an extract :—

Class.	Character.	Minimum Illumination. foot-candles.
A	Important street..	.. 0·15
B	Well-used street ..	.. 0·044
C	Best residence street	.. 0·075
D	Ordinary residence street	0·06 (about)
E	Suburban residence	.. 0·005
F	Country Roads ..	.. 0·00017

It is interesting to compare the above figures with those suggested by the Joint Committee in England, who graded the streets as follows :—

Class.	Character.	Minimum Illumination. foot-candles.
E	Important streets	.. 0·06 to 0·1
D	Good-class district	.. 0·04 „ 0·06
C	Average London district	0·025 „ 0·04
B	Residential London district ..	.. 0·01 „ 0·025
A	Poorer class district	.. 0·01 and below

FIG. 6.

FIG. 7.

These were also classified as first class main lines of thoroughfare, auxiliary roads, side and unimportant streets, but very brilliantly-lighted streets as Whitehall and Cheapside were not included, nor did they deal with small suburban or country roads.

It will be noted that the above table compares closely with that of Mr. Lacombe. It is therefore surprising that this method of grading and specifying street lighting requirements has not been adopted.

It is even more surprising that in America, after much discussion, it was decided to specify the type of lamp rather than the results it was desired to obtain.

In a country so noted for rapid development it would be thought that means would be adopted to encourage the designing of special apparatus to obtain results rather than to bar progress by specifying apparatus which already existed but had not been specially produced for the purpose.

These remarks naturally refer to the past, and I have lately noted a tendency in America to devise special fittings for street lighting purposes.

In the discussion to-night I hope the question of requirements will be carried another step forward, as I feel certain that illuminating engineers are now in a better position than they ever have been to fulfil such requirements, and if left to tackle the problem in a scientific manner will, with the experience they have already gained, produce the desired results more efficiently and economically than many Municipal Authorities realise is possible.

Mr. Haydn T. Harrison, in concluding his paper, expressed his great pleasure at the presence of their late President, Mr. A. P. Trotter. He personally owed a great deal to Mr. Trotter, and he recalled the classic paper read by him before the Institution of Civil Engineers in 1891, which covered the field so completely, and on which so much of what he (Mr. Harrison) had done in connection with street lighting was based. On reading the paper again he had been struck by the fact that subsequent advances had been mainly on the lines suggested by Mr. Trotter on that occasion. It was most fitting that he should preside on this occasion when they were taking up the subject of street lighting again.

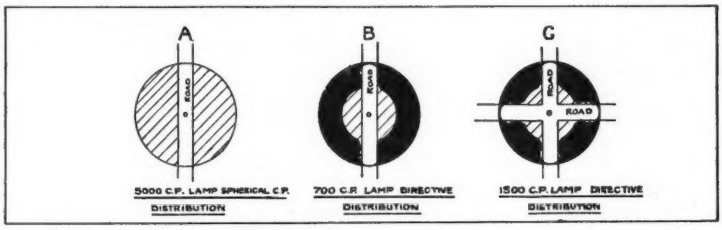

FIG. 8.—The longitudinal system of street lighting.

THE COST OF STREET LIGHTING.

IN a recent contribution to the *General Electric Review* (U.S.A.) Mr. H. A. Butler discusses the cost of public lighting. Few people realise that the expenditure on the lighting of highways forms but a small part of the total cost of upkeep. Mr. Butler presents diagrams showing that the running cost of lighting, on the method described, works out to about 10 per cent. of the maintenance of reinforced concrete roads, bituminous macadamised roads, and even less in the case of those made of reinforced concrete.

STREET LIGHTING AND SAFETY.

By L. GASTER

(Contribution to the Discussion at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, December 12th, 1922.)

IT has been suggested that, as a supplement to the introductory paper presented by Mr. Haydn T. Harrison, some remarks on the relation of street lighting to safety of traffic would be of interest. The importance of this question was brought vividly before us during the period of the war, when the rapid increase in the number of street accidents gave rise to much concern. In the London Metropolitan Police District the number of fatal accidents increased from 424 in 1913 to 493 in 1914 and 666 in 1915; the recorded non-fatal accidents from 13,153 in 1913 to 14,638 in 1914, and 16,366 in 1915. These conditions led in 1916 to the formation of the London "Safety First" Council, which has done so much to diminish accidents in the streets of London, and with whom the Illuminating Engineering Society has worked in cordial co-operation from its commencement.

It was generally agreed that the diminution in street lighting was one of the main causes of this rapid increase in mishaps, though doubtless there were other contributory factors. The matter was discussed on frequent occasions in the Society's official organ.* While the method of presenting statistics, and the absence of certain details of information, made it difficult to draw accurate conclusions, one important fact was elucidated. Whereas, during the period 1913 to 1915, non-fatal accidents occurring in the daytime increased by 34 per cent., non-fatal accidents *by night* increased by 63 *per cent.*; similarly fatal accidents during the daytime increased by only six per cent., whereas fatal accidents *at night* increased by 21 *per cent.* This alone was enough to show that lighting was a material factor, and at the opening meeting of the Society in 1918† the writer suggested a schedule for the collection of data on a uniform basis, which would afford valuable and conclusive information. Similar suggestions in regard to accidents in factories have also been conveyed in a recent contribution of the writer to *Safety First*, the official organ of the British Industrial "Safety First" Association.

The original methods of screening lights in London were fully discussed before the Illuminating Engineering Society, one of the chief objections being the irregular distribution of light, leading to sharp contrasts in the illumination of the roadway. Ultimately it was found that the conditions necessary for the safety of traffic, namely, uniform illumination and absence of sharp contrasts in brightness, were also those desirable from the military standpoint, and accordingly better methods of screening the public lights were introduced. Mr. A. P. Trotter gave us a delightful and instructive account of his survey of London at night from an airship in his Presidential Address in 1917.*

The tabulation and study of statistics on street accidents in 32 American cities with a combined population of over seven million, was undertaken by Mr. E. A. Anderson and O. F. Haas, in a paper presented at the 15th Annual Convention of the Illuminating Engineering Society in the United States last year. Of the 31,475 accidents recorded, roughly 30 per cent. occurred during the hours of darkness. The method of collecting these data enabled the accidents to be tabulated both for hours of the day and months of the year, and the authors were able to show that 17·6 per cent. of the accidents occurring after dark were attributable to inadequate lighting.

It is noteworthy that, according to recent reports, there has been marked progress in the United States in public lighting. Indeed, the N.E.L.A. has recently remarked that during the past year street lighting was the only phase

* ILLUM. ENG., Nov. 1916, p. 334; Dec. 1916, p. 371; Feb. 1917, p. 38.

† ILLUM. ENG., Jan. 1918, p. 14.

* ILLUM. ENG., Dec. 1917, p. 317.

of electric lighting activity in which the progress was unimpeded. In this country, owing to the fact that progress was at a standstill during the war, there must still be much leeway to be made up. Doubtless financial stringency is mainly responsible for neglect to make good the deterioration of the war-years, but, as Mr. Harrison has pointed out, in many cases the substitution of more efficient and up-to-date appliances would lead to savings which would soon cover the costs of installation. The present time, when many firms are in need of work and the widespread unemployment is giving serious concern, appears to be an opportune one for putting in hand such street lighting improvements, which would in any case become inevitable in the near future.

Among the chief characteristics of street lighting desirable from a "safety" standpoint may be mentioned: (1) Avoidance of glare in the eyes of drivers or pedestrians from unduly bright sources of light; (2) promotion of reasonably uniform illumination, and avoidance of sharp contrasts in brightness at different parts of a street; (3) suitable "grading" of the intensity of illumination in passing from a side street to a main street (or *vice versa*), or from one local district to another, so that inconvenient sudden changes in illumination are absent.

Also the part played by certain forms of private lighting cannot be overlooked. Glare from street-lamps is objectionable, but the use of powerful unscreened lamps, either in show-windows or as external sources outside buildings, is also prejudicial to the safety of traffic. In this respect, a useful lesson was conveyed by the experience of the war when the screening of lights in windows was made obligatory and many people realised for the first time the benefits of concealed lighting. Well-diffused illumination, such as is afforded by concealed lighting of show-windows, is a valuable supplement to public lighting as it tends to smooth out the sharp shadows and imperfect illumination of objects necessarily arising from the use of isolated public lamps with big distances between them. Flood-lighting of the surfaces of buildings, such as has recently been applied to a few buildings in London, likewise adds useful diffused illumination. Whatever encouragement local authorities can give to judicious methods of private external lighting, of a soft and pleasing nature, will also contribute to the safety of traffic in the streets.

In conclusion I would like to recall one other lesson of the war period, to which reference has been made in THE ILLUMINATING ENGINEER on several occasions—the need for some form of central supervision of the lighting of London as a whole. During the war all areas in London willingly adopted the measures required by the authorities in order to secure uniformity of method in street-darkening. Could we not, in times of peace, derive similar benefit from the supervision of a central authority, able to deal with *all* the various aspects of street lighting, including safety requirements, and bring about greater uniformity of practice throughout the Greater London area?

Whatever views may be held as to the utility of the method of testing proposed in the Draft Standard Specification on street lighting, as a basis of contracts, the classification of streets according to illumination requirements is admittedly a valuable feature. A useful preliminary step towards greater uniformity would be the inspection and classification of all the main thoroughfares according to their lighting requirements. Attention could then be devoted mainly to those streets in which the conditions of illumination were obviously inadequate in view of the nature of the traffic. The experience thus gained would doubtless serve as a guide to other leading cities throughout the country.

In a paper read before the London Society in 1914 the writer traced the development of public lighting from the days when householders were required to hang out lanterns, up to the present time when each local borough makes its own arrangements. The lighting of roads—particularly main thoroughfares and important arteries of traffic—is not a parochial but a national matter, and it would appear that the time has come when public lighting, like the upkeep of road-surfaces, should be supervised by an appropriate central authority and conducted on a uniform plan.

RECENT DEVELOPMENTS AND MODERN REQUIREMENTS IN STREET LIGHTING.

DISCUSSION.

Dr. CLAYTON SHARP (Past-President of the Illuminating Engineering Society in the United States) said that he could hardly say how much pleasure he felt in being able to be present at one of these meetings. He had been connected with the American Society since its inception, and had watched with the greatest interest the formation and growth of the British one. He had the very keenest admiration for the excellent work it had done.

He did not claim to be an authority on street lighting, but he had done some work on those lines. Mr. Harrison had referred to the Report of the Street Lighting Committee of the National Electric Light Association. This report had been based on extensive tests, as practical as could be, of street lighting made in the city of New York, and extending over many weeks. A considerable section of a quiet street had been practically given over to experimental work, and various typical lighting systems had been installed there. A rather complicated system of wiring had been put in, so that different lighting units could be used, different arrangements tried, and the various combinations which might enter into the solution of the lighting problem be investigated. The attempt had been made to get some really quantitative results as to the effectiveness of different kinds of lighting. Experiments had been made with lamps down the centre of the roadway, lamps placed alternatively on opposite sides, lamps on one side only, and so forth. Among other tests, blocks of wood painted about the same colour as the pavement had been distributed along the road, and young men had been sent in an automobile to see how many of these could be detected. The experiment was also tried with the same men walking in the street, and again with the blocks of wood replaced by pieces of sheet iron about the size of the licence plate of an automobile.

In the result the Committee had been impressed with the fact that the elements which entered into good street lighting were extremely complex; there was no single criterion of good street lighting. To specify, as Mr. Harrison did in his paper, the minimum illumination standard as the one criterion was not adequate and one of the statements in the paper itself brought out the same point. The paper pointed out that by raising the lamps the minimum illumination could be increased without any change in the lamps themselves. This was true, but was the lighting of the street thereby improved? Raising the lamps would decrease the maximum illumination, and it was a question whether this decrease would not do more harm, than the increase of the minimum illumination would do good. As he had said it was a complex question, and it was chiefly because of its complexity that the National Electric Light Association had not laid down any values for minimum illumination, or attempted to draw up a specification for street lighting on which tenders could be made on the basis of illumination values. They had rather taken the view that the practical thing to do was for lighting companies to contract with municipalities for the installation and operation of the lamps and for the maintenance of candle-power values of the lamps within certain limits. Then the thing contracted for was perfectly definite and the fulfilment or non-fulfilment of the contract became a matter very easy to determine. Furthermore, he did not think it was practicable to make an adequate specification on the basis of minimum illumination values, because of the uncertainty of the determination with any degree of accuracy of the illumination of the street. They might have value

for minimum illumination going down to the hundredth part of a foot-candle; this could not be measured with accuracy even in the laboratory; it was out of the question in the street. The decision taken in America to specify the type of lamp rather than the illumination had not proved a bar to progress; on the contrary the lighting companies were keen to introduce new and improved fittings; they wished to give better lighting and to increase the popularity of their service. He had been much interested in what Mr. Harrison had said about the longitudinal system of lighting; for certain classes of streets this was the logical system to apply. Over ten years ago he (Dr. Clayton Sharp) in the "Transactions" of the American Illuminating Engineering Society, had described an arrangement to do the same thing. It must be remembered that the light which was thrown upwards was not lost if there were fine buildings to illuminate; but in the absence of these and where economy in the use of light is important, and in lighting sparsely settled districts, a longitudinal system had much to recommend it.

Mr. FRANK BAILEY said that his education in illuminating engineering had commenced in 1892 when he had had the privilege of being present at the meeting of the Institution of Civil Engineers to hear the historic paper which Mr. Trotter had read on that occasion. His education had been continued as a member of the Joint Committee which had endeavoured to place the whole question of street lighting on a more scientific basis. Mr. Trotter had been one of their most active members on that Committee, in the good work of which Mr. Harrison and Mr. Gaster had also participated.

The Committee had tried to get accepted the great fundamental principle that as a basis of street lighting contracts one should specify a minimum horizontal illumination which could be measured at any time, guaranteed, and contracted for. The benefit of good street lighting was not usually appreciated because it was so seldom experienced, and one had to put up with what was no more than "pilot lighting."

During the war we were taught how to appreciate darkness, but the time has now come when all this gloom should disappear and a much higher standard of illumination should be adopted. Mr. Gaster had shown on the screen a diagram of the candle feet horizontal minimum illumination of various streets, and it was interesting to note that Cheapside was apparently lighted luxuriantly. He ventured to suggest that the time was now due, and much overdue, for the adoption of this standard for all main streets. Every householder should be able to find his own house, and to see the hole for his latch-key without striking matches.

The Author mentioned street traffic, and as there was a possibility of the present speed limit being removed there would be an increased danger unless street illumination was improved. In these days of rapidly driven vehicles it was hazardous to allow motor cars to depend on their own headlights. Such headlights might be necessary until something better replaced them, but they were responsible for glare and caused many accidents. Adequate street lighting should render these very powerful headlights unnecessary, and there was no reason—or ought not to be any reason—why every motor car should be a travelling lighthouse and be equipped like a mobile generating station. Take the case of a vehicle going at 20 miles an hour—that was 30 feet a second. If a pedestrian took 3 seconds to cross the width of the car, it was necessary to see the car 100 ft. before he began to move across the street. That could not be done with ordinary street lighting as we knew it to-day.

Another point was as to the width of streets. In conveying water through pipes if we wanted to increase the rate of flow we obviously increased the head of water at the intake, and if we wanted to get more traffic through the streets we must increase the speed, but could not safely do this without good illumination. The alternative was to widen the streets; but he had made a calculation that if extra lighting would enable such a widening to be postponed, each additional lamp might save £1,500 per annum.

Capt. W. J. LIBERTY, referring to Mr. Harrison's standard example, said that he had set a very high ideal in stating that if the minimum horizontal illumination is taken as the criterion of street lighting the illumination would at the distance and height street lamps are usually placed be more than doubled by doubling the height of the lamps and increased nearly eight times by having the distance apart of the lamps.

These very conditions were in vogue in all the main roads in the City of London and had been since 1912; the height of these centrally suspended lamps being from 25 to 27 feet above the centre of the roadway, and the distance apart a little over 30 yards—say 100 feet. He claimed that they had succeeded in getting main roads that were absolutely shadowless. Cheapside—which came out highest on the tables shown on the screen—was, he admitted, a bit spectacular, but it was essentially the one shopping thoroughfare in the City. So evenly was the City's main roads lighted that it was possible to walk the whole length of the thoroughfare at night and read a newspaper, or pick a pin from the roadway, whilst the police could read the numbers on the back of swiftly propelled motor vehicles with ease, and, what was more important, foot passengers could see the approach of motor vehicles from one end to the other. It was a fact that a large percentage of accidents to foot passengers took place at night; in the City of London they were practically immune. He worked on the principle that for the purposes of the prevention of crime, a lamp was as good as a policeman, whilst from a "Safety First" point of view a well-lighted main thoroughfare diminished accidents.

They had some cause to be proud of the City's street lighting, as they had received visits from many municipal authorities and deputations from Japan, America and other countries, who had expressed their admiration of the system.

Mr. S. B. LANGLANDS (Public Lighting Inspector, City of Glasgow) said that the method of lighting adopted in different classes of streets differed considerably. Some principal thoroughfares were overlighted rather than otherwise. Public lighting was often of greatest utility after midnight as very material assistance was derived from the light from shop windows, illuminated signs, etc., in the earlier part of the evening. In the City of Glasgow, lighting of main thoroughfares was effected mainly by means of flame arcs, rated at 2,000 candlepower, at a height of 20-25 feet and spaced 40-50 yards apart. In pre-war days the lesser tramroutes were lighted by double incandescent gas burners consuming 5·6 cubic feet per hour, and yielding 112 candlepower, at a height of 10 feet. Single burners were used in the quieter streets. In 1914 there were 1,700 electric lamps and 25,360 gas lamps and the total expenditure was £75,604 per annum. For 1921-22 the estimated expenditure was £159,359. The public lighting of the City covers about 500 miles. The Lighting Authority controlled the planning of the illumination, the choice of lamps and candlepower, and their maintenance, so that there was no need to lay down a specification for a contractor to work to.

He would submit a copy of the report for the past year. This dealt largely with proposals for electric lighting, but they were also experimenting very carefully with some of the newer types of gas burners and also with pressure governors, etc. It was hoped that the cost of lighting would be brought down to something between the pre-war figure and the £313,000 (which included both the figure for public lighting mentioned above and the lighting of common stairs, involving some 85,000 stair lights).

The great increase in volume and speed of vehicular traffic would necessitate better street lighting in future, and this problem was being considered. Mr. Langlands mentioned some figures showing conditions of illumination obtained with the directive type of lantern mentioned by Mr. Harrison. Thus in a section of one of the narrower streets about 40 feet broad, lighted by one 350 w. gasfilled lamp in a directive fitting, 27½ feet above the ground, values of horizontal illumination (one metre above road) were as follows:—Under

lamp on centre line 0·95 foot-candles; 10 yards along street, 0·41, 20 yards along street 0·44, 40 yards along street 0·067. In another stretch of street with two similar fittings 50 yards apart there was a maximum of 0·52 foot-candles, and 0·107 midway between lamps.

In another street it was decided to remove centre pillars as dangerous obstructions and 350 w. lamps in prismatic bowls were attached to span-wires supported by pillars at the kerbs. Maximum values on centre line of 0·34 and 0·74 foot-candles were recorded and values midway between spans (20-22 yards away) ranged from 0·94 to 0·12.

In dealing with public lighting authorities it was desirable to use terms that were intelligible to them. The "foot-candle" was easily explained, but such terms as lumen, lux or lambert presented great difficulties. A steady electrical voltage and constant pressure and calorific value from gas were of great importance; otherwise estimated results were not borne out in practice. They had been experimenting with a member of the University staff in connection with headlights and had devised what seemed a suitable means of diminishing dazzle, the parabolic reflector being halved and one half moved backward or forward relatively to the other. The idea, however, had been patented in years gone by. In Glasgow motorists switched off their bright headlights and trusted to the street illumination.

He appreciated Mr. Harrison's simple methods of illustrating the advantage of placing lamps at a judicious height. In Glasgow they had adopted heights of 30 feet in certain cases with lamps of 2,000 candle-power (nominal).

Maintenance would play a large part in determining future methods of street lighting. He was glad to note that the Institution of Gas Engineers had appointed a Committee to inquire into the behaviour of gas burners. In the Glasgow laboratory they had obtained some remarkable results by making quite simple adjustments and the behaviour of what should, theoretically, be good burners was sometimes erratic and uncertain.

Mr. J. G. CLARK said the question of street lighting was undoubtedly of very great importance, and would become very much more so in the future. The bogy of economy would have to be buried sooner or later. It seemed to him that this Society should have a rule that the subject of street lighting should come up for discussion at least once in every two years, so that its members might keep abreast of the times and know what requirements had to be met.

The statistics quoted by Mr. Gaster were very arresting indeed, but there were naturally other factors to be considered. In comparing the dark hours with the daylight hours, one naturally thought of the people walking about the roadways as being in a state of fatigue relatively to what they would be in the other part of the day. Therefore while those figures were doubtless in part attributable to street lighting the influence of natural fatigue making people less alert should be taken into account. As Mr. Gaster had pointed out, more complete statistics were needed in order to obtain conclusive evidence of the effect of inadequate illumination.

Mr. Harrison in his paper had alluded to the fact that the desirable minimum illumination invariably led to glare. On the other hand Mr. Gaster had laid down the principle that for safety's sake there must be no glare and at the same time a uniform illumination. This was admittedly asking for two conditions which were very difficult to reconcile one with another. How were we to get really uniform horizontal illumination without glare? It would seem that the perfect shading of lamps was practically an impossible thing; and that we might do better by asking people to shade their eyes. Complete absence of glare seemed almost unattainable, but it had occurred to him that variable glare was one of the worst forms. For instance, in the case of a lamp that was very highly unidirectional one had not merely the actual glare of the bright source, but the change in brightness viewed from different directions. This was more distressing than a steady glare.

He noticed that Mr. Harrison seemed to be very definitely in favour of the classification of streets on a minimum

illumination basis, and stated that this principle was scientifically sound. It was a view that was held by many, but Mr. Harrison seemed not quite sure of it; because he alluded with some favour to some of the results obtained in America as showing the importance of silhouetting against bright backgrounds; which seemed to indicate some importance for *maximum* horizontal illumination values. Visibility was what was wanted, but the difficulty was to know what constituted visibility. Dr. Clayton Sharp had indicated the complexity of the problem; and anyone who had studied street lighting, and tried to get it on a really scientific basis, would be more and more convinced of its complexity. With regard to the value of uniform illumination, he had looked up some reports embodying work done in America. One such report summarised the result of an experimental study of street illumination carried out in New York City in 1916. The object had been to discover the bearings of uniform and non-uniform illumination on the safety of a thoroughfare with rapidly moving traffic. The experiments had been made on the basis of psychology, and the data were rather complex; but the conclusions apparently were that a street was safer with a certain range of illumination than the same street would be with perfectly uniform lighting along its whole length.

Mr. R. DAVISON (City Lighting Dept., Newcastle-on-Tyne) has extended his remarks as follows:—

It has given me a great amount of pleasure this evening to have had the opportunity of listening to the papers on street lighting read by Mr. Harrison and Mr. Gaster, and as a Lighting Superintendent who feels his responsibilities I am of the opinion that the Society is doing useful work in devoting some of its time to the subject of street lighting.

Mr. Harrison has mentioned the nuisance caused by powerful headlights, and I quite agree that the street illumination should be of such a character as to obviate the use of powerful headlights. It has been interesting to hear Mr. Harrison's remarks on the longitudinal system of street lighting, more so as we have a number of these lamps fixed in Newcastle-upon-Tyne. We are obtaining all the results which Mr. Harrison claims, and up to the present time we have not heard of any complaints from drivers of vehicles as to any interference of vision by glare from the light source.

I might mention that this class of lamp is fitted on standards in the centre of the roadways, which to my mind is an admirable position for the longitudinal system of lighting where the width of the street permits. It is pleasing to note that manufacturers are interesting themselves in the problem of street lighting, which will be of considerable help to those who have the responsibility of lighting our cities.

Mr. Leon Gaster's remarks on the relation of street lighting to safety of traffic are very interesting and offer scope for serious thought to those responsible for the lighting of our streets. Mr. Gaster informs us that the tabulation and study of statistics on street accidents in 32 American towns revealed the fact that 17·6 of the accidents were attributable to inadequate lighting. This is very serious. I don't know of any record of accidents we have for a similar number of towns in England, but if it is anything like the American towns, then I say that the Lighting Authorities have good arguments in favour of increasing expenditure for the improvement of street lighting, as I think where life is concerned finance should be a secondary consideration. There is not one in this room to-night but would like to improve the lighting of his district even to the extent of affording facilities for finding the keyhole of doors, as suggested by one of the previous speakers, but the question of cost is always present, and it is a subject which must be taken into consideration if we are to do our little bit towards stabilising our economic position.

In conclusion, I should like to suggest to the Society that, if they could find means of interesting Lighting Authorities all over the country by propaganda, or, as I am attempting to do in Newcastle, by bringing to the notice of the Lighting Committee the doings of the Society, it would, I feel sure, be of considerable

help to the officials in carrying out the work of street lighting.

I should like to add that I am indebted to the City Lighting Committee of Newcastle-upon-Tyne and also the Illuminating Engineering Society in affording me facilities to attend this instructive meeting.

Capt. H. L. THOMSON, M.I.E.E., said that he had the honour of having been for many years Chairman of the Public Lighting Committee of the City of Westminster, and he would be very sorry to allow a meeting of this importance to be held in that City without his giving his meed of praise to the remarks that had been made. The subjects dealt with that evening had been vast, and each speaker had dealt with a separate aspect of them; so that one could quite profitably preach a little sermon on any of the texts that had been put forward. It had been remarked that candlepower was the only standard for contracting. He might mention that for the first time for over twenty years he (the speaker) had succeeded in abolishing, or getting round, an old contract under which the greater part of the City of Westminster had been lighted. This contract had been made by the old Vestry, the predecessors of the present Council, and it specified that the Company was to put up a certain number of lamps, the only qualification being that those lamps must consume a certain amount of current; there was absolutely no mention of any light at all! (Laughter.) Under those circumstances, as could readily be imagined, the improvement of the lighting presented difficulties. However, the trouble had been got over now, and Westminster could claim to be pretty well on a par with the rest of the civilised world.

His main object in speaking, apart from expressing his thanks to the lecturer and other speakers, was to emphasise a remark made by Dr. Clayton Sharp that the light thrown up above was not wasted; he had been trying to induce his Committee to deal with the decorative effect of light in relation to building. In this northern climate, during the winter months, we were abroad a good deal in the hours of darkness, and although we spent tens of millions putting up the most beautifully decorative buildings, we absolutely neglected the lighting effect upon them—he was not speaking of the lighting effects of enterprising traders. There ought to be a combination between the architect designing a building and the public authorities, so as to ensure uniform and decorative lighting. For instance, the Automobile Club was a beautiful building, and he was a member of its Committee. For the last ten years he had been trying to get the lighting improved, so that the whole façade should be uniformly lighted. With this object he was trying to bring the Committee of the Club and the Electric Lighting Committee of the City of Westminster into line on the matter, but as yet had not succeeded. He would ask the Society to make a special point of trying to get those who were interested in improved lighting to work together. Of course there were many difficulties in placing the lamps, there were so many things to consider; among others the fact that they could not indefinitely multiply the number of lamp-posts. There was a great tendency to clear the streets of such obstructions, and the City of Westminster had now power to attach lamps to buildings—a power which the City of London had possessed for many years—and he hoped that some day lamp-posts would become things of the past, fine brackets taking their place. This should get over the trouble of spacing and the brackets could easily be a decorative feature. (Applause.)

The CHAIRMAN (Mr. A. P. Trotter), in calling upon Mr. Harrison to reply to the discussion, remarked that a considerable variety of points had been dealt with. Gas and electric lighting engineers were ready to meet any requirements of local authorities, with whom the responsibility for public lighting rested, and it was for these authorities to give lighting experiments the opportunity of seeing what they could do.

Capt. E. STROUD (*communicated*): There is no doubt that street lighting throughout the country greatly needs improvement. The subject is a very wide one, and I would suggest that in

future this general discussion might be supplemented by treatment of various constituent problems in detail.

I agree that a great improvement would be effected if it was generally recognised that sources should be placed at a greater height. As Mr. Harrison has pointed out, the minimum illumination could be more than doubled if street lamps spaced in the customary manner were mounted at twice the present height. The rays would then strike the street surface at a less oblique angle and in addition the trouble of glare would be diminished.

I think, however, that in the examples quoted Mr. Harrison has taken somewhat extreme cases for the ratio of distance between lamps to height of suspension. Thus he mentioned lamps 180 feet apart and 12 feet high, a ratio of 15 to 1, which is surely exceptional for other than by-streets. I notice that Mr. Harrison stated that in the Holophane prismatic street-lighting unit an increase in candlepower of 2 to 2½ times the average has been obtained in the desired direction. I may mention that by producing a similar prismatic reflector the increase has now been raised to 4-4½ times, which is a distinct improvement. It should also be noted that the light is distributed over a considerable diffusing area so that glare is to a great extent minimised—a result which is less easy to obtain by mirror-reflection.

Mr. Harrison has remarked that "by the circular distribution area much of the luminous energy is used in brilliantly illuminating either the frontage adjacent to the light or the surrounding country which formed no part of the road or street." But in order to illustrate this point he takes the extreme example of lamps 180 feet apart and 12 feet high, with a road width of 40 feet. In a more average case, *e.g.*, a ratio of distance to height of 6 : 1 or 8 : 1 and a width of roadway of 60 feet-80 feet, the width of the street is about half the distance between the posts. Hence the circular distribution of light is approximately correct for illuminating the opposite side of the road and also its length, and relatively little light is distributed on adjacent frontages.

The disadvantage of a strictly longitudinal system is that one obtains an extremely narrow asymetrical distribution which may be likened to the beam of a motor car headlight pointing in two directions up and down the street. Thus the zone over which one gets ten times the lamp candlepower projected may be about 5° at an angle of 7½° below the horizontal, but the candlepower rapidly diminishes past this point and after 15° practically reverts to the natural distribution of light from the lamp. With a confined beam of this nature, and mirrors of comparatively small area, avoidance of glare becomes a difficulty.

In conclusion I would like to refer to the lighting conditions in Northumberland Avenue or Whitehall where Holophane refractors have been installed by the Charing Cross Electrical Supply Co., as an instance of good effects obtained with the so-called "circular" distribution of light.

Mr. A. CUNNINGTON (*communicated*): In looking over the various designs of street-lighting fittings, the distribution diagrams, and the estimates of illumination likely to be obtained, one is tempted to ask "How long will it last?" As one concerned quite as much with the upkeep as with the installation of lighting systems I make no apology for emphasising the importance of maintenance and putting it down as one of the prime considerations in design.

It will be noted that consideration of the lasting power of the illumination to be supplied suggests a number of things which should be avoided in an ideal street lighting fitting, *e.g.:* (1) Complexity of parts which would lead to heavy cost in renewals; (2) an excess of glassware which is bound to lead to heavy loss of efficiency on account of dirt deposited, unless a disproportionate amount is expended on cleaning; and (3) lack of durability under bad weather conditions, which points to the elimination of thin sheet-metal spinnings unless heavily enamelled, and the use as far as possible of substantial castings with strong bolts and nuts, etc. Small brass parts are an especial pitfall in this connection. I am aware that if the above considerations were pressed too far they would put out of court all scientific treatment of the street-lighting

problem and would reduce the street lamp to the barest source of light, but they should at least be always in mind when fittings are being designed.

Perhaps I may also draw attention to the influence of the maintenance consideration on other points. Supposing one were deciding between two gas lamps one of which gave considerably higher efficiency than the other in the laboratory test, it might easily be that an extra facility for cleaning and renewal of parts in the lamp with lower efficiency would completely outweigh the gain in efficiency. Again, in judging between the various methods of avoiding glare, one would give preference to the use of white enamelled backgrounds which would tone down the apparent brilliance rather than the use of complex diffusing globes which almost inevitably harbour dirt and rapidly become inefficient. Lastly, the cost of maintenance may actually be, in cases where gas or electricity is cheap, a large part of the total cost of street lighting. Take the following example :—

Street lighting by one hundred 300 watt gasfilled lamps burning 4,000 hours per annum :—

Current Cost per annum.

120,000 units at 6d... ...	= £3,000

Maintenance Cost per annum.

500 lamp renewals at 13s. 6d.	= 337
Other items	= 43
Wages for attendance and cleaning	= 220
	£600

Alternative Current Cost per annum.

120,000 units at 1d... ...	= £500

It will be seen that in the above imaginary case if electricity were supplied at 6d. per unit the annual cost of current would be five times as much as that of maintenance. But suppose current should be supplied at a special contract rate of 1d. per unit, the cost of current would be actually less than that of maintenance.

I am sure that Mr. Haydn Harrison would be the first to admit from his practical experience the importance of maintenance, and doubtless if the length of his paper had permitted he would have dealt with it as one of the " Modern Requirements of Street Lighting." I would ask designers to saturate themselves with the maintenance idea before putting their fittings on the market.

In his contribution to the discussion Mr. J. G. Clark referred to the " Bogy of Economy " as practised by Local Authorities, but I take it that he rather meant the bogy of *parsimony*. Economy is after all the second half of efficiency, which is getting the best for the least cost, and as Illuminating Engineers we are all striving for efficiency. It is regrettable that the word economy should have a stigma cast upon it by being confused with inadequacy and inefficiency.

Mr. JUSTUS ECK (*communicated*) : Street-lighting provision needs periodic revision due to the increasing use of roads for passenger and goods traffic, and to the higher speed of the vehicles and both papers submitted are most timely.

The illumination of all streets must be improved and with the increasing efficiency of high power electric and gas light sources the running costs need not rise appreciably. The periodic scrapping of obsolete lamps and burners is also no serious matter.

For improved distribution it is not essential to alter the distribution of the lamp standards or the pipes and cables supplying these, for gas lighting has always been by direct connection on the main pipe while electric lamps burn with perfect satisfaction on the series arc lamp circuits, which, in view of the very high efficiency of the arc lamp, should be retained for its promised revival as the premier light source.

The contention that standards should be higher and at shorter distances in order to increase horizontal illumination at the distant points is practically a fallacy, as Mr. Haydn Harrison admits, in the latter part of his paper, when he quotes " that obstructions of which the illumination was only one-tenth of those near the light source were more visible due to the sharper silhouetting," thus showing that vertical illumination is more important than horizontal.

Increased illumination in thoroughfares should enable the glaring headlights of motor cars which are the fruitful cause of accident to be eliminated without appreciably reducing speed, thus securing economy of usage and increased safety.

The present low standards of illumination cannot be tolerated much longer in either towns or villages and I consider the time is now come for the minimum street illumination to be nowhere less than 0·1 foot candles, while that of country roads should not be less than half this.

Fittings of the class designed by Mr. Haydn Harrison will be of great use for country roads, but for streets with houses lanterns with extensive circular distribution fitted with dioptric glasses like the Kandem Extensive will give better effect due to the reflected light from the buildings.

The importance of grading, as pointed out by Mr. Gaster, is of the greatest moment, and for this reason alone it is desirable that Greater London should have a "central authority" to control street lighting.

Mr. W. J. JONES (*communicated*): I have listened with great interest to the discussion that has been opened by Mr. Haydn T. Harrison and Mr. Gaster and feel that we should be indebted to them for bringing such important matters to our notice. It is surely now time that we began to deal with street lighting more thoroughly and to more adequately define what is to be considered good lighting for a given purpose. A great deal has been said in favour of measuring the value of illumination by taking readings of foot-candles on a horizontal plane, but it must be remembered that although such data may be contributory, yet the only final test is the ability to distinguish objects readily at a distance. I can quite conceive the roadway lighted uniformly without being of much aid to vision, for the vertical component of illumination helps considerably in the definition of objects and obstructions.

I was delighted to have the opportunity of listening to Dr. Clayton Sharp of America giving definite information on this particular matter and almost entirely agree with the remarks which he has made.

I have noted Mr. Haydn T. Harrison's remarks relating to the advantage of placing units close together, but personally prefer high power units spaced a reasonable distance apart. I see little opportunity in busy streets or indeed good class residential districts with wide roads, for small lamps on short columns. In busy thoroughfares the fact that the lighting units are some 20 feet above the ground helps distant vision, since the object and light source do not subtend the same angle with the eye as is the case of short standards. Members of the Illuminating Engineering Society will appreciate that this materially increases the sensitiveness of the eye, for a bright source of light in the immediate field of vision impairs the acuity of eye.

An excellent instance of suburban lighting with large gasfilled lamps on high columns is to be found in North St. Pancras. The lighting obtained is good and in every way pleasing.

As regards "directional" methods of street lighting, one must bear in mind the fundamental difficulty of combining suitable modification of distribution in light with avoidance of glare. Although the method does give perhaps good distribution of light viewed from the point of view of uniformity, yet the intensity of the beam emitted in an oblique direction is so great that the problem of glare becomes formidable. In my opinion the distribution obtained by the use of the Holophane Refractor glassware represents the limit to which one can comfortably go in the direction of designing fittings with bat's-wing polar curves.

May I now for a few moments deal with the question of gasfilled lamps and advocate the adoption of low voltage series burning units, with the use of substitutional resistances of positive action as that of the Acme Type. Low voltage lamps are stronger in every way than those of high voltage for the filament is of a much larger cross sectional area, and it must be remembered that the strength varies approximately with the 4th power of the diameter, *i.e.*, a lamp of say 50 volts is capable of withstanding as regards filament, some 256 times as much

shock. Moreover lamps of low voltage give some 15 per cent. more light for a given wattage than do those of high voltage.

It is interesting to note that in one London Borough 1,000 large gasfilled lamp units are in use and very long life of lamp is obtained.

A further note of interest in connection with these lamps is the fact that when switched "on" there is an instantaneous rush of current amounting to 13 times that consumed normally, and I have obtained some oscillograms which illustrate this fully. These records show that there is very little electrical inertia, as might have been expected since the filament is coiled, the only effect noticeable being that due to the positive coefficient of resistance of the tungsten, and the time it takes to heat up.

Mr. HAYDN T. HARRISON said that, after considering what had been pointed out in the discussion, he still held that the principle of basing specifications for street lighting primarily on the minimum horizontal illumination was scientifically sound. There might be difficulties in applying the principle in practice, but in the future these should be overcome. Dr. Clayton Sharp had suggested that such illuminations as 0·01 foot-candles could not be measured with sufficient accuracy. He (Mr. Harrison) thought that if measurements were correct within 10 per cent. this would be sufficiently accurate for many purposes, and mentioned that on the evening before his assistant had been measuring values as low as 0·004 foot-candles, and in that case the error had not been more than 7 per cent.

As regards the longitudinal system of street lighting he agreed that the fundamental idea was not new; he had himself described it in a paper as early as 1905. Its utility naturally depended to some extent on the kind of street. He would not suggest it for illuminating a street with high buildings having facias worth lighting; it was rather a system to be used in the average street or road where, on account of economy, posts had to be spaced far apart, and where it was desirable to get as much light on the roadway as possible.

Mr. Langlands had undoubtedly a difficult problem to deal with in the public lighting of Glasgow, with its five hundred miles of streets of different types and requiring individual treatment. Naturally no one system could answer in all cases. He hoped, however, that in dealing with large cities authorities would not be content merely with lighting the main streets well, but remember that even the slums should not be left in comparative darkness.

Mr. Clark somewhat misinterpreted his views in supposing that he (Mr. Harrison) attached great importance to uniform illumination. He did not suggest that uniformity should be obtained at the expense of total amount of light. But if one had only a certain amount of luminous flux to expend on a given area, and one wished to work to a minimum illumination as high as possible, it was obvious that the maximum must be reduced to get the best results. The uniformity was effected not by sacrificing light but by taking the excess from one direction and concentrating it in others where it was needed.

He agreed with Mr. Davison's remark that municipal authorities should be educated to appreciate the value of good public lighting more highly. He was also interested to hear Mr. Thomson's views regarding the use of fixtures attached to buildings in Westminster. In many cases street-lighting units so mounted were not only less expensive to install but more effective than long rows of lamps mounted on posts.

[An account of the above meeting, contributed by Dr. Clayton H. Sharp to the Transactions of the Illuminating Engineering Society in the United States (February, 1923, p. 225), contains an appreciatory account of the discussion. Special reference is made to the presence of lighting inspectors from different parts of the country. In conclusion, the hope is expressed that it may some time be possible to arrange a joint meeting of the British and American Societies, which would be of the greatest interest and profit to both organisations.]

PUBLIC LIGHTING BY GAS.

In a paper on the above subject read before the Manchester and District Junior Gas Association on January 13th, Mr. E. Burke remarked that during the war few utility services were so disorganised as the public lighting departments of various towns. The public became so inured to doing without proper lighting that, even now, it is only in a few cases that public lighting has reached anything like pre-war conditions.

Mr. Burke gave an account of pre-war experimental lighting in Birmingham, which included centrally hung high pressure lamps equipped with traversing, raising and lowering gear, and 1500—4500 high pressure lamps on 30 ft. columns on island junctions in main thoroughfares. An interesting device was the use of three low pressure " Littleton " lamps on certain islands, the highest and middle ones being fitted with ruby globes and used as " safety first " traffic regulators, designed to replace a policeman on duty.

At present the city has about 22,000 public lamps and 220 lamplighters, an inner circle being hand-lighted and an outer circle automatically. The author described the system in detail, mentioning that the period allowed for lighting up of lamps by hand is 1¼ hours, the time being so selected that the process is completed one hour after sunset. Lamps that fail to light up are notified, and systematic arrangements are made for regular cleaning. Maintenance men patrol the district in order to replace broken chimneys, etc., and the police are instructed to obtain any information of street accidents which result in lamp-damage.

Excellent results were obtained with the special Birmingham upright burner, which was so effective that it held up the introduction of inverted burners for a considerable time. The testing of mantles and burners is described. The burners must not pass 0·05 cubic feet less or more than the predetermined amount of gas (an increase of this amount per burner would mean 5 million cubic feet added to the leakage account). Mantles purchased have to pass certain gauges. It is remarked that two mantles of the same reputed size have been known to differ by 30 per cent. as regards the amount of gas needed to fill the mantle ; this is equivalent to a difference of 20 per cent. in the light furnished for a given amount of gas.

CHANGES IN GAS LIGHTING IN GERMANY.

In a paper delivered at the recent annual meeting of the Illuminating Engineering Society in Germany, Dr. H. Bunte referred to the changes in the constitution of the gas supplied occasioned by the lack of coal during the war period and after. The effect had been to produce a hotter and narrower flame, for which pre-war shapes of mantles were not well suited. It was necessary that the mantles should now be made of smaller diameter so as to ensure that the fabric was located in the hottest part of the flame.

EDUCATION IN INDUSTRY AND COMMERCE.

At a meeting of the Association for Education in Industry and Commerce, held in University College on December 31st, 1922, there was an interesting discussion, one of the chief features being an address by Mr. R. W. Ferguson, in which various schemes of promoting the education of young people and adults in industry were discussed. Representatives of a number of firms described the methods of education pursued. Such matters as training in salesmanship now receive attention from leading firms, but the view was expressed that too narrow a view of education should not be taken, and that the general welfare of employees, as well as their instruction in matters bearing directly on their vocation should be borne in mind.

Principal Schofield, of Loughborough College, who delivered an address on the place of education in industry, made special allusion to this aspect of the problem, and also dwelt on the importance of continuity in experiment and research in order that information might be handed on to the workers of the future.

An account of the discussion is to be found in *Education* (January 5th, 1923).

THE EFFECT OF LIGHTING CONDITIONS ON OUTPUT IN COAL MINES.

ATTENTION has been called to the importance of lighting conditions in mines by the discussion before the Illuminating Engineering Society in February, 1920,* and again in the report issued by the Miner's Nystagmus Committee last year.† It was shown that the disease of the eyes known as miner's nystagmus is mainly due to deficient illumination, and it has been generally recognised that lighting conditions have an intimate relation to output.

The results of some interesting researches by Messrs. E. Farmer, S. Adams and A. Stephenson on this last point, summarised in the *Journal of the National Institute of Industrial Psychology* for January, 1923, are of great interest.

Shading of Filaments.

One of the first points studied was the effect of glare from the exposed filament, which, though of small candlepower, may appear a very bright object amidst such dark surroundings. The miner is apt to leave the lamp in one position, which may be suitable while he is working with the pick on the coal face, but may cause the light to shine directly into his eyes when he turns to shovel coal into a tub, or dirt into the pick. Experiments were made with the lamp in various positions relative to the subject. It was found that exposures of two seconds ensured after-sensations of sufficient duration to be measured and compared. When the filament is immediately facing the eye of the miner the effect is a maximum. Most subjects reported an image corresponding with a crescent-shaped filament, but in some cases there seemed to be several "dancing about," a fact which is partly accounted for by reflections in the glass of the cylinder. Such after-images must interfere with steadiness of regard, power of discrimination, accuracy of aim, etc.

In order to study the effect of diffusing the light the glass cylinder of the miner's lamp was slightly obscured with hydrofluoric acid, and the tests were repeated. Whereas with the ordinary lamp the average number of after-images was 3·4 and their average duration 48·4 seconds, with the diffusing cylinder the average number was 1·7 and the average duration 23·8 seconds. It would appear, therefore, that the diffusing effect of etching the glass led to an appreciable diminution of glare, and this was confirmed by the examination of a man who suffered from nystagmus; he found that the after-image was almost stationary with the etched cylinder, and it is suggested that oscillatory and other movements of the after-image might be used as a confirmatory test of suspected nystagmus. The etching of the cylinder occasioned a loss of 28 per cent. of light. Nevertheless, in 15 cases tested acuity was better with the diffusing cylinder, in 9 cases the same, and in only 4 cases better with the bare lamp.

Distribution of Light.

The shape of the filament gives a maximum light in a direction perpendicular to the crescent. The candlepower in the "end on" direction is only two-thirds of the maximum. As the lamp is hung on a prop in the coal face it would be advantageous to arrange that the plane of the filament is the same as that of the ring handle. Measurements have shown that one-sixth of the light is cut off by the prop on which the lamp is hung, and it is therefore recommended that the lamp should be furnished with a reflector (attached to the handle) not exceeding one-sixth of the circumference of the cylinder. This device would have the additional advantage of shielding the light from the view of men behind, when the miners are walking in line, as in these circumstances the view of the lights in front is apt to prove troublesome.

Experiments with Increased Illumination.

The great difficulty in increasing candlepower is the corresponding increase in weight necessary to provide an accumulator of adequate capacity. It is generally believed that a lamp heavier than the present one would be objected to by miners. Accordingly the investigators asked for volunteers to use a porch lamp which gives six times the light of an

* ILLUM. ENG., March, 1920.
† ILLUM. ENG., March, 1921.

ordinary lamp but is about five times as heavy. Volunteers were readily forthcoming, and one man carried the lamp for eight weeks. His output and dirt-deduction * for this eight-week period was as follows :—

OUTPUT OF COAL—	Tons.
Average output of coal per man per shift before use of big lamp ..	2·47
Average output of coal per man per shift during use of big lamp ..	2·83
Increase	0·36
Percentage improvement ..	14·57

DEDUCTIONS FOR DIRT—	Tons.
Before use of big lamp	16
During use of big lamp	12
Reduction of dirt	3·5
Percentage decrease	21·87

* Dirt is the material in which good coal is found. The amount that gets mixed with the coal is deducted weekly from each miner's output.

If a miner will carry this great increase in weight *voluntarily* for a period of eight weeks one may suppose that the weight of the existing electric lamp might be at least doubled without becoming a handicap. The beneficial effects of the increased illumination would allow of a margin which would permit diffusion of the light by a slightly obscured cylinder, and thus add to the miner's comfort and powers of vision.

CORRESPONDENCE.

THE THEORY OF VISION.

SIR,—There is no subject in which a revision of the statements made is more required than that of vision. Theories are given as facts when there is very little to support them except misstatements. This is particularly the case with the theory that supposes that the rods are percipient elements for perception in a dim light, whilst the cones are the percipient elements in daylight. This theory is a very irrational one, for it is difficult to conceive an element stimulated by the decomposition of a photochemical substance which is excited by a weak light and not more strongly by a brighter light. What is the supposed function of the rods during the daytime? Apart from the numerous facts against this theory, it will be found that it is supported almost entirely by misstatements—namely : (1) That certain animals have only cones and others have only rods ; (2) that the periphery of the retina is colour-blind ; (3) that the eye is totally colour-blind in dark adaptation ; (4) that the Purkinje phenomenon and the recurrent image are not found with the fovea. 1. Though I have examined numerous collections I have never been able to find any animal with only rods or only cones, neither have I found anyone who has seen such a retina. The tortoise is the most quoted, it is stated only to have cones ; the rods and cones in the retina of the tortoise are as clearly defined and distinct as in the human retina. 2. The periphery of the retina is not colour-blind when colours of sufficient intensity are used. The reader can test this for himself with a doctor's red lamp. He will find he can see it as red to the extreme periphery. 3. In dark adaptation the eye is not totally colour-blind ; those interested in the subject should read the masterly paper by Burch on "Colour Vision by Very Weak Light."* Lately I have found that the colour of the yellow spot may be demonstrated by weak light. If three white discs, each two inches in diameter, be fastened on a black ground in a dimly-lighted room, in a line with an interval of two inches between them, on viewing them so that the centre one falls on the yellow spot, this appears darker and orange-yellow, whilst the two others appear bright bluish-white. There is no scotoma corresponding to the rod-free portion of the macula which is equal to a visual angle of about 3°. 4. The Purkinje phenomenon and recurrent image are found with the fovea.

All the facts point to the visual purple being the visual substance and that vision takes place by stimulation of the cones through its decomposition by light.—I am, Sir, yours faithfully,

F. W. EDRIDGE-GREEN.

London.

January 26th, 1923.

* Proceedings of the Royal Society, Vol. lxxvi., B, p. 199.

INDEX, January, 1923.

TOPICAL AND INDUSTRIAL SECTION.

OVERHEAD SUSPENSION GEAR FOR STREET LIGHTING.

A feature of modern methods of street lighting, which was originally introduced in the City of London, and has since become popular in many cities, is the practice of suspending lamps centrally over the roadway by means of wires spanning the street. From the standpoint of light-distribution the method has much to recommend it, and there is the additional advantage that lamp-posts, which may be an inconvenience in narrow streets, are avoided.

We have received from the London Electric Firm, who specialise in suspension gear of this type, some particulars of the recent installation of electric lighting at Hove, where central suspension has been used with good effect. It is pointed out that variations in the sizes of buildings are no bar to the suspension system, as short poles can be erected on a low building or attachment made to a chimney stack or the like, where opposite buildings are of unequal height.

SIMPLEX INDUSTRIAL LIGHTING FITTINGS.

A catalogue issued by Messrs. Simplex Conduits, Ltd., describes a number of useful fittings for industrial lighting, including weather-proof lanterns, cargo cluster lights, steel reflectors, semi-indirect and bulkhead fittings. There are also some introductory notes on the selection of units to provide a specified foot-candle intensity. Attention is drawn to the special deep tops which can be supplied fitted complete with the new pattern anti-vibrator device to the majority of the fittings listed.

AN ATTRACTIVE CALENDAR.

We have received from the Metropolitan Vickers Electrical Co., Ltd., their new "Girl" Calendar for 1923-24. On this occasion the Publicity Department, after a thorough search among the beauties of the Stage and Press Beauty Competitions, have selected Miss Mamie Watson as the subject.

"THOR" ELECTRIC SAFETY LAMPS.

We have received an illustrated booklet describing several recent types of "Thor" electric safety lamps, in which material improvements have recently been made. Amongst these is included a pillarless type of lamp which secures a considerable improvement in light-distribution, and is equipped with a nickel-plated reflector to shield the light from the eyes of men following one another. A form of cap lamp is also illustrated, the battery being mounted on the back of the miner, attached to his belt, and the lamp, equipped in a compact aluminium case, mounted over his forehead and connected to the battery by insulated wire protected by flexible metallic tubing.

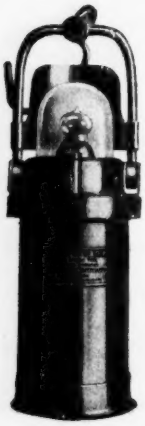

FIG. 1.—General view of "Thor" Pillarless Lamp.

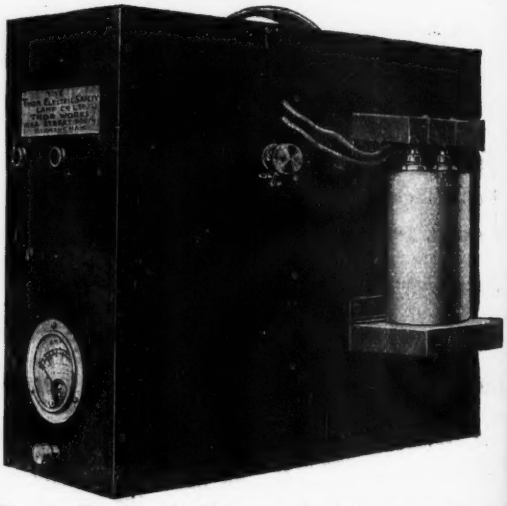

FIG. 2.—Thor Portable Photometer for testing miners' lamps.

Another useful form of lamp is the large "M" type for shaft and roadway work, which contains four cells in series supplying an 8-volt 6-candlepower lamp, the whole weighing about 25 lbs. This has various special features, and should prove of value in all cases where a good light is essential and the additional weight involved is not of consequence.

Readers may also be interested in the portable photometer for testing miners' lamps. The case contains a standard 2-volt lamp, supplied from a battery through a rheostat and Weston ammeter, and is arranged to take any of the well-known makes of miners' lamps for test. Additional arrangements can be provided to facilitate tests of bulbs and well glasses, and both ammeter and voltmeter can be provided to indicate the current and pressure of lamps examined.

THE GASFILLED LAMP.

A booklet, issued by the General Electric Co., Ltd., prepared by the Staff of the research Laboratories, contains an illustrated and lucid account of the principles underlying the construction of the gasfilled lamp. The consequences of the filament being surrounded by heat-conducting gas, instead of being in vacuo, are discussed, and there is a clear explanation of the reasons why relatively thick filaments in gasfilled lamps are desirable. This leads to an account of the method of spiralising thin filaments, whereby the necessary resistance is obtained but the heat loss in the gas is materially diminished.

MACBETH ARTIFICIAL DAYLIGHT.

A catalogue, issued by A. D. Lang, Ltd., contains particulars of a variety of Macbeth artificial daylight units, and an article reproduced from "Textiles" describes the use of the "Fade-ometer" for testing the permanency of colours. The apparatus utilises a special arc rich in ultra-violet light within a cabinet, having a series of exposure-openings. We are asked to mention that the business has been transferred to larger premises at 42, Berners Street, London, W. 1.